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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/843,622	04/26/2001	John S. Petersen	2790.1001-001	7679

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EXAMINER

SAGAR, KRIPA

ART UNIT	PAPER NUMBER
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1756

DATE MAILED: 12/02/2002

9

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/843,622

Applicant(s)

PETERSEN, JOHN S.

Examiner

Kripa Sagar

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 4/26/01, 10/7/02.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-19,38--68 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-19,38-68 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 26 April 2001 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☒ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 4. 6) ☐ Other: _____

DETAILED ACTION

Election/Restrictions

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:
 - I. Claims 1-19, drawn to a method of phase shifting, classified in class 430, subclass 311.
 - II. Claims 20-37, drawn to a phase shift mask, classified in class 430, subclass 5.
2. Inventions I and II are related as process of making and product made. The inventions are distinct if either or both of the following can be shown: (1) that the process as claimed can be used to make other and materially different product or (2) that the product as claimed can be made by another and materially different process (MPEP § 806.05(f)). In the instant case the process as claimed can be used to make other and materially different product such as an LC array mask.
3. Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, restriction for examination purposes as indicated is proper.

4. During a telephone conversation with Attorney Christopher Lutz on 9/26/02 a provisional election was made with traverse to prosecute the invention of method of phase shifting, claims 1-19. Affirmation of this election must be made by applicant in replying to this Office action. Claims 20-37 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.
5. The above restriction, is being placed on record, but it is now moot in view of the cancellation of claims 20-37 in the pre-amendment dated 10/7/02.

Response to Amendment

6. The preliminary amendment filed on 10/7/02 has been entered. Claims 20-37 have been cancelled. New claims 38-68 have been added. No new matter has been added. Claims 1-19 and 38-68 are under consideration.

Claim Rejections - 35 USC § 112

7. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.
8. Claims 8,9,38-68 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claims 8 and 9 recite the limitation "first beam portion" and "second beam portion". There is insufficient antecedent basis for this limitation in the claim. The claims depend from claims 7 and 1 which have no reference to multiple beam portions. Claim 3 does refer to the first and second beam portions.

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Claim 9 further recites a strong phase shift “ is operable to balance opposing electric fields between the first beam portion and the second beam portion”. The scope of this claim is not clear. The spatial symmetry of the assist features may be required to balance the electric fields or the opposed amplitudes may be such that the intensity is balanced. The precise definition of “balance” is not clear from the specification.

Claim 38 recites the limitation of “approximating in a frequency domain the phase and amplitude via a Fourier Transform at a lens pupil plane”. It is understood that the projection system performs a Fourier Transform of the mask at the back-focal plane of the objective. The significance of a further approximation by a Fourier Transform in the context of imaging is not clear.

Claims 39-68 depend from claim 38.

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

10. Claims 1-16, 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Pat. 5229230 to Kamon in view of US Pat.6004699 to Yasuzato et al.

The invention is directed towards a phase shift mask with assist features and design rules for making the mask.

The claims recite phase shifting a beam through a phase shift mask comprising primary and auxiliary features; the beams passing through these features are shifted by an odd multiple of 180 deg. In addition the auxiliary features are designed such that the zero-order intensity of the primary feature is eliminated by the opposed amplitude of the assist features. The features may be formed by an additive or subtractive process.

Kamon teaches focusing a source of actinic beam through a phase shift mask (Fig.11) to produce a phase shifted beam and forming an image on a substrate to be etched according to the pattern (3;16-33). The transmitted beam consists of a main pattern and an auxiliary pattern. The light transmitted through the auxiliary patterns is opposed in phase by 180 deg. to that transmitted through the main pattern. (Fig.2). The main pattern is an isolated two-dimensional feature (Fig.1,3). Thus Kamon teaches all the elements of claims 1-10,16 and 19.

Kamon does not teach forming the main feature and the assist (auxiliary) features by subtractive or additive process.

Yasuzato's efforts are directed towards a phase shift mask with assist features for imaging an isolated pattern. Masks formed by the additive process (Fig. 3B) and subtractive process (Fig. 4,5) are known in prior art.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to form auxiliary patterns by the conventional additive or subtractive process, as taught by Yasuzato, on Kamon's phase shift masks because these are well known techniques and there is a reasonable expectation of successfully forming these auxiliary patterns required by Kamon.

11. Claims 17,18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kamon in view of Yasuzato as applied to claims 1 and 4 above and further in view of US Pat. 6401236 to Baggenstoss et al.

The instant claims recite simulation of the exposure process and adding multiple assist features.

Baggenstoss teaches the design of assist features to eliminate sidelobe formation in phase shift masks. Multiple pairs of assist features (250) are utilized (fig.4). Baggenstoss teaches that the design is verified by an exposure simulator to identify the sidelobes and the location of the assist features. Subsequently the design with the added features is again verified with the simulator (Fig.2).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use an exposure simulator to place multiple pairs of assist features as taught by Baggenstoss on a phase shift mask designed according to Yasuzato and Kamon because Baggenstoss teaches that it is less time consuming than empirical methods (3;11-17).

12. Claim 38 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kamon in view of Baggenstoss and further in view of US Pat.5316896 to Fukuda et al.

The instant claim is directed towards a method of imaging with a phase shift mask and using Fourier Transform (FT) to analyze the pattern.

The teachings of Kamon have been discussed above. Kamon teaches imaging a source of radiation onto a phase shifting mask and forming a pattern on an imaging layer and transferring the pattern on to a substrate by etching. Assist features are

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included on the phase shifting mask to prevent unwanted artifacts and ensuring intended features are printed. Kamon thus teaches most of the elements of claim 38.

Kamon does not teach analysis of the image.

Baggenstoss teaches simulation of the exposure process with a mask but does not teach FT.

Fourier transform of the mask layout provides the amplitude and phase distribution at the focal plane of the object lens. Fukuda teaches the use of the transform to approximate the image on the substrate layer, through convolution with a pupil function (Fig.1). The inverse transform provides the corrected mask layout pattern (3;34-41). Fukuda's effort is directed towards mask design.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to design a mask using FT as taught by Fukuda to design the phase masks of Kamon and verify them with a simulation as taught by Baggenstoss because Fukuda teaches that, with this design method a large depth of focus (DOF) and high image quality are obtained at the same time (Abstract).

13. Claims 40-68 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kamon in view of Fukuda as applied to claim 38 above and further in view of Yasuzato and further in view of Baggenstoss.

The instant claims recite the limitations on the structure of the mask.

The teachings of Kamon, and Fukuda have been discussed above.

Kamon teaches fabrication of the substrate by etching after patterning with a mask (cl.40). The phase-shifted beam comprises a plurality of beam portions that

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interfere at the pupil plane(cl.42-47). Kamon's main feature is an isolated feature (cl.58) which is two dimensional (cl.68). The mask is formed on a glass substrate (3;1) and the assist features are formed of SiO₂ (3; 12), which have a transmittance between 0 and 1.0. (cl.63-64).

Kamon does not teach forming the mask with additive or subtractive process. It does not teach simulation or multiple features.

Fukuda teaches a method of determining the transmittance(cl.41) of the mask (Fig.1)

Fukuda does not teach forming the mask with additive or subtractive process. It does not teach simulation or multiple features.

Yasuzato teaches forming phase shift masks by additive or subtractive process (cl.59-62). They are known in prior art.

Yasuzato does not teach simulation or multiple features.

Baggenstoss teaches simulation and placement of multiple assist features. The use of computing facility(cl.56-57) is indicated (fig.9). The number of computers in parallel required for the process depends on the speed and capacity of the computer.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to perform a FT analysis as taught by Fukuda on Kamon's mask with the assist features formed by Yasuzato's methods, using Baggenstoss' simulation technique in designing the assist features because Fukuda teaches that the analytical process leads to a mask designed with a large depth of focus (DOF) and high image quality, while Baggenstoss teaches that simulation of the mask before fabrication leads

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to saving in time and Yasuzato teaches that the technique of forming the assist features is conventional and there is a reasonable expectation of success in forming the structures by that process.

14. Claim 39 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kamon in view of Fukuda as applied to claim 38 above, and further in view of non-patent publication of Smith. ("Optics for Photolithography"; B.W.Smith, in Microlithography; B.W.Smith and J.R.Sheats eds.).

The instant claim recites the limitation of FT of the mask image using a sinc function.

This function is fundamental to the transform and is discussed in the monograph on Microlithography by Smith(p188-192).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use a sinc function, as taught by Smith, in the analysis of the mask image as taught by Fukuda in the design of Kamon's mask because this is well known, conventional and provides a reasonable expectation of successfully analyzing the wavefront using this function.

Conclusion

15. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

US Pat. 6411642 to Mazed teaches phase mask design and the annulment of the zero-order beam (3;6-12). However the phase mask is designed for forming optical gratings and is not related to the placement of assist features.

US Pat. 6320648 to Brueck et al. teaches the basic principles underlying diverse resolution enhancement techniques (RETs) including, phase shifting, off-axis illumination (OAI) and Imaging Interferometric Lithography (ILL). In all of these techniques the elimination of the zero-order diffracted beam leads to an increase in resolution and depth of focus. However Brueck does not teach designing assist features using these rules.

The novelty of the invention lies in (a) performing a FT analysis of the mask pattern and analyzing the frequency and phase domain and (b) designing assist features to null or attenuate the zero-order frequency based on the analysis in (a). The claims as written fail to distinguish the invention from prior art where (a) strong and weak phase shifting masks with assist features are designed empirically (as noted by Applicant) and (b) where zero-order frequency is annulled or attenuated by other means (see Brueck).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kripa Sagar whose telephone number is 703-605-4427. The examiner can normally be reached on 8:00AM--5:00PM (M-F).

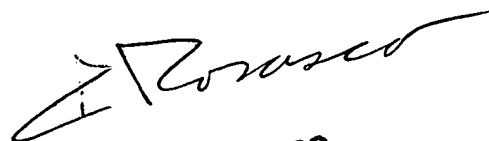
If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark F Huff can be reached on 703-308-2464. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9311 for After Final communications.

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Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

MH/ks

November 24, 2002

A handwritten signature in black ink, appearing to read "S. Rosasco", written in a cursive style.

**S. ROSASCO
PRIMARY EXAMINER**